

No. 2. — *Maldive Cephalochordates, with the Description of a New Species from Florida.* By G. H. PARKER.

Introduction.

THROUGH the kindness of Mr. Alexander Agassiz, to whom my thanks are due, I have had the privilege of studying the cephalochordates collected by him in his recent expedition to the Maldive Islands. These consisted of material from three localities. At Timarafuri, Kolumadulu Atoll, a single specimen of the rare *Branchiostoma pelagicum* Günther was taken in the net between one hundred and fifty fathoms and the surface; at Nalandu, Miladummadulu Atoll, a single specimen of a new species of *Heteropleuron* was dredged in twenty-four fathoms; and at Hanimadu, Tiladummati Atoll, the dredge brought up from sixteen fathoms twenty-one specimens as follows: twelve *Heteropleuron maldivense* Cooper, two specimens of a new species of *Heteropleuron*, and seven specimens of a new species closely related to *Asymmetron lucayanum* Andrews. The exact positions of these localities are well shown in the chart accompanying Mr. Agassiz's (1903, Plate 1) account of his voyage.

In addition to this material I have also studied that in the collections of the Museum of Comparative Zoölogy and of the United States National Museum. In the former I found seven specimens of a new species of *Asymmetron* from the coast of Florida. A description of this species is included in the present paper.

I am indebted to the officers of the National Museum and of the Museum of Comparative Zoölogy, especially to my friend Dr. W. McM. Woodworth, for the use of the collections under their charge.

Description of Species.

While it is perhaps premature, in view of the rapidly increasing number of species, to discuss at any length the classification of the cephalochordates, a survey of the recent literature on the subject shows that the species thus far known fall more or less naturally into three groups, which have at least the taxonomic value of genera.

The first of these is Costa's original genus *Branchiostoma*, which, though somewhat restricted by new definitions, has been retained by Kirkaldy

(1895), Gill (1895), Willey (1901), and Tattersall (1903^a), and is defined by all excepting Kirkaldy for the inclusion of symmetrical species only.

The second is Andrew's *Asymmetron*, which was accepted in its original form by Kirkaldy (1895) and by Gill (1895), but expanded by Tattersall (1903^a) to include all unsymmetrical species, whether they possessed a urostyloid process or not.

The third is Kirkaldy's subgenus *Heteropleuron*, which was raised by Willey (1901) to generic value for the reception of all unsymmetrical species, including those originally put under *Asymmetron*.

These three genera may be briefly defined as follows:

1. *Branchiostoma*. — Symmetrical cephalochordates in which the right and left metapleural folds terminate just behind the anus and the gonads form two lateral series.

2. *Heteropleuron*. — Unsymmetrical cephalochordates in which the left metapleural fold terminates just behind the anus, and the right one is continuous with the median ventral fin; the gonads form a single series on the right side; and a urostyloid process is not present.

3. *Asymmetron*. — Unsymmetrical cephalochordates in which the left metapleural fold terminates just behind the anus and the right one is continuous with the median ventral fin; the gonads form a single series on the right side; and a well developed urostyloid process is present.

As already indicated, species representing all three genera were found by Mr. Agassiz in the Maldives, and their descriptions follow.

***Branchiostoma pelagicum* GÜNTHER.**

Günther, 1889, p. 43.

Plate 1, Figs. 1, 2.

A single specimen of this somewhat rare species was taken in the net between one hundred and fifty fathoms and the surface at Timarafuri, Kolumadulu Atoll. This species was originally described from a single specimen taken by the "Challenger" a few degrees north of Honolulu in the Pacific. A second specimen obtained by Mr. J. J. Lister, in the Indian Ocean midway between Madagascar and Australia, was reported on by Cooper (1903, p. 352) in his account of the Maldivian and Laccadive cephalochordates. Finally six specimens formed the basis of an account of this species by Tattersall (1903^b, p. 214); all six were taken by tow-net in the Indian Ocean, one about halfway between Perim and the Maldives, and the other five between the Maldives and the Gulf of Manaar. Notwithstanding these several catches, all three lots of material were reported as poorly preserved, and consequently the best description of this species that could be compiled is still defective in several important particulars.

The specimen obtained by Mr. Agassiz is exceptionally well preserved, and the following notes based upon an examination of it are intended to supplement former descriptions.

The length of the specimen is 9 mm. and its depth 0.8 mm., being slightly smaller than the "Challenger" specimen, though having almost exactly the same proportions. Cooper's specimen had the considerable length of 21 mm., though, as his figure shows, its depth was proportionally as great as that of the "Challenger" specimen: Tattersall's largest specimen was 8.5 mm. long and 1 mm. deep, thus agreeing fairly well with the measurements of the small individuals already given. Tattersall's drawing (1903^b, Fig. 16), however, represents, probably by mistake, a more slender animal. Notwithstanding the slight differences in the dimensions of the various specimens, they probably all belong to one species.

The fins in the specimen taken by Mr. Agassiz were in perfect preservation. The caudal fin (Plate 1, Fig. 2) is oval in outline and almost exactly symmetrical dorsoventrally. The chorda extends through its major axis, and ends close to its posterior edge. The fin dorsally and ventrally is marked with numerous delicate radiating striae.

Dorsally the caudal is continuous with a dorsal fin, which can be followed to the anterior end of the animal. Near the tail (Fig. 2) it is moderately high, but it gradually becomes lower and lower, till near the anterior end (Fig. 1) it is about one-third as high as at its posterior limit. In the posterior region a row of low fin-ray chambers can be seen (Fig. 2). These increase in height, and near the middle of the trunk reach the outer edge of the fin. At the anterior end they rapidly diminish in height, and cease near the eye-spot (Fig. 1). They contain no fin-rays.

A low ventral fin without fin-ray chambers connects the caudal fin with the right metapleural fold.

Anteriorly the dorsal fin is continuous with a rostral fin (Fig. 1) which expands ventrally and posteriorly to join the buccal hood on the left side.

The number of myotomes in the specimen under examination is sixty-seven, corresponding in this respect exactly with the "Challenger" specimen. Cooper's specimen contained at least sixty, and Tattersall's sixty-five, though, as the authors state, neither of these counts can be relied upon as accurate because of the poor state of the material.

The myotome formula for this species had been provisionally stated by Kirkaldy (1895, p. 320) as $36 + 16 + 15 = 67$. This was based upon a tentative statement by Günther (1889, p. 43), in whose specimen the atriopore could not be identified with certainty. In our specimen the atriopore and anus were distinctly visible, and the myotome formula proved to be $46 + 10 + 11 = 67$.

The notochord, which is well developed, reaches from very near the anterior edge of the rostral fin almost to the posterior limit of the caudal. At both ends it projects well beyond the myotomes.

The nerve tube contains in its anterior end a well developed eye-spot and,

beginning at the third myotome and extending almost to the posterior end, a series of smaller spots in groups irregularly twice as numerous as the myotomes.

The gonads form two series, one right and one left, though, as intimated by Günther (1889, p. 44), they are often so closely pressed together near the median plane that they there seem to form a single median row. The presence of a double row of gonads places this species unquestionably in the genus *Branchiostoma*.

The number of gonads on each side was thirty-three, and the series ranged from the first to about the twenty-ninth myotome instead of the twenty-sixth, as in the "Challenger" specimen. Our specimen is probably a male, though the gonads were not sufficiently mature to allow this determination to be made with certainty.

I can confirm the statement of most previous writers that oral cirri are absent. I have also been unable to find any evidence of branchial apparatus, and I agree with Cooper (1903, p. 353) that if this apparatus is present at all, it must be very limited in extent. Possibly the small size and flattened form of this species, which must place very near the surface all the living substance in need of oxygen, may have been acquired in connection with a gradual loss of specialized respiratory organs in much the same way that many of our smaller salamanders seem to have lost their lungs.

Heteropleuron maldivense COOPER.

Cooper, 1903, p. 349.

Twelve specimens of this recently described species were dredged in sixteen fathoms of water at Ilanimadu, Tiladummati Atoll. They agreed in all particulars with the very full account of this species given by Cooper. The more important structural relations as shown in three of the specimens are given in Table I.

TABLE 1.

STRUCTURAL CHARACTERISTICS, ETC., OF *H. MALDIVENSE*.

No. of Specimen.	Length in mm.	Sex.	No. of Gonads.	Myotome Formula.
1	19	♂	23	$42 + 16 + 12 = 70$
2	17.5	♀	24	$43 + 16 + 11 = 70$
3	16	♀	23	$43 + 16 + 12 = 71$
Mode			25	$45 + 16 + 12 = 73$
Range			8	5 4 4 7

These records agree fairly well with those tabulated for this species by Punnett (1903, p. 363), from whose table the modes and ranges at the base of Table I. are taken.

Heteropleuron agassizii, sp. nov.

Plate 2, Fig. 5.

One specimen of this species was dredged in twenty-four fathoms of water at Malandu, Miladummadulu Atoll. It is rather elongated, measuring 27 mm. in length by 3 mm. in depth. The dorsal fin is of almost uniform height throughout. From the anal region to a point a little in advance of the anterior end of the nerve tube, it contains fin-ray chambers to the number of four or five to a myotome. In the anterior and posterior regions these fail to reach the free edge of the fin, but in the trunk region they meet the edge. The most anterior three chambers are without fin-rays, which are present in all the more posterior chambers to a point about midway between the atriopore and the anus. From this point posteriorly, only faint traces of fin-rays are here and there observable, and even these disappear as the caudal region is approached. Never more than one fin-ray is present in a chamber. Often in the anterior region and sometimes posteriorly the fin-rays may reach to half the height of the fin, but in most places they are only about one-fourth this height. Anteriorly the dorsal fin is continuous with the rostral. Posteriorly it passes into the simple inconspicuous caudal fin which in turn is continuous with the ventral. The ventral fin has much less height than that part of the dorsal fin opposite to it, and is without fin-rays or fin-ray chambers.

The myotome formula is $45 + 15 + 10 = 70$.

The chorda is stout and almost reaches the anterior and posterior limits of the body, projecting well beyond the myotomes in both directions.

The nerve tube has a faint anterior eye-spot followed by a series of smaller spots reaching from the third to the last myotome, and showing the usual tendency to fall into two groups for each myotome.

The gonads form a single series on the right side, and are twenty-four in number. They extend from the seventeenth to the forty-first myotome. The specimen is a female.

The oral region is so contracted that it is impossible to be certain of the number of preoral cirri; at least nine to a side are present.

Heteropleuron agassizii is related to *H. bassanum*, and especially to *H. maldivense*. In length it is between *H. bassanum* (43 mm.) and *H. maldivense* (22 mm.). The ratio of its depth to its length, one to nine, is almost exactly that of *H. bassanum*, and less than that of *H. maldivense*, one to six. The gonads, which in *H. maldivense* begin between the ninth and thirteenth myotomes and extend to a point between the thirty-third and thirty-ninth, in *H. agassizii* extend from the seventeenth to the forty-first. The caudal fin of *H. agassizii*, though much like that of *H. maldivense*, differs strikingly in its

simple outline from the more lancelike form of that of *H. bassanum*. Perhaps the best differential character lies in the ventral fin. In *H. bassanum* and *H. maldivense* the ventral fin has fin-ray chambers and fin-rays; in *H. agassizii* it has no chambers and no fin-rays. A summarized statement of the contrasts between *H. agassizii* and other allied species is given in Table 2, page 45.

***Heteropleuron parvum*, sp. nov.**

Plate 2, Fig. 6.

Two specimens of this species were dredged in sixteen fathoms of water at Hanimadu, Tiladunmati Atoll. They measured 11.5 mm. and 12.5 mm. in length respectively, and their depth is about one-tenth their length.

The dorsal fin is well developed, and is slightly higher posteriorly and especially anteriorly than in the middle. It has well marked fin-ray chambers extending from the anterior end of the nerve tube to the tail, and numbering about four to a myotome. In the middle region the chambers reach the free edge of the fin. Single fin-rays are present. Anteriorly the dorsal passes into the rostral fin, posteriorly into the inconspicuous caudal. The caudal fin, which is in no way marked off from the dorsal, is also continuous with the ventral, which contains a series of low fin-ray chambers and short single fin-rays. These are inconspicuous, and have not been shown in the figure (Plate 2, Fig. 6).

The myotome formula in both specimens is $40 + 18 + 10 = 68$.

The chorda is stout and almost reaches the anterior and posterior limits of the body.

The nerve tube contains a conspicuous anterior eye-spot, and from the third myotome to the last a series of smaller spots.

The gonads, which were completely present in only one specimen, formed a single series on the right side, and were sixteen in number. They extended from the fourteenth to the thirtieth myotome.

The structure of the ventral fin allies this species with the first four mentioned in Table 2. It differs from all these in its small size and narrow form, for it is even longer in proportion to its depth than *H. bassanum*, the narrowest of the four. From *H. bassanum* it differs markedly in its myotome formula, the small number of its gonads, and the simpler form of its tail.

A comparison of *H. parvum* and *H. agassizii* with other allied species is given in Table 2.

TABLE 2.
COMPARISON OF STRUCTURAL CHARACTERISTICS, ETC., OF *HETEROPLEURON AGASSIZII*, *H. PARVUM*, AND OTHER ALLIED SPECIES.

Name of Species.	Length in mm.	Ratio of Length to Depth.	No. of Gonads.	Myotome Formula.	Condition of Ventral Fin.
<i>H. bassanum</i> Günther . . .	43	9 : 1	26 to 31	45 + 16 + 14 = 75	Chambers with fin-rays.
<i>H. hectori</i> Benham . . .	53	7 : 1	18 or more	53 + 19 + 12 = 84	" " "
<i>H. maldivense</i> Cooper . . .	22	6 : 1	23 to 30	45 + 16 + 12 = 73	" " "
<i>H. cingalense</i> Kirkaldy . .	27	8 : 1	20 to 26	39 + 16 + 8 = 63	" " "
<i>H. parvum</i> , sp. nov. . . .	12	10 : 1	16	40 + 18 + 10 = 68	" " "
<i>H. cultellum</i> Peters . . .	35	7 : 1	17 to 20	32 + 10 + 10 = 52	Chambers; no fin-rays.
<i>H. agassizii</i> , sp. nov. . . .	27	9 : 1	24	45 + 15 + 10 = 70	No chambers nor fin-rays.

Asymmetron orientale, sp. nov.

Plate 1, Fig. 4.

Seven specimens of this species were dredged in sixteen fathoms of water at Hanimadu, Tiladummati Atoll. They varied in length from 18 mm. to 9 mm., and their general proportions and structural features suggested at once that they belonged to the species *Asymmetron lucayanum* Andrews. Although the material on which Andrews based his description came from the Bahamas, Cooper (1903, p. 348) has recently claimed that the same form also occurs in the Maldives. In discussing this question he states that "the only point in which the Maldivan and West Indian forms consistently differ from one another is in their size. The average length of the Maldivan specimens is 23 mm., the extremes being 18 and 30 mm., thus being nearly double the length of the Bahama specimens which Andrews found to average 13 mm. In spite of this difference the average myotome formula for the two forms remains practically the same, the mode in each case being sixty-six myotomes, *i. e.* forty-four from the head to the atriopore, nine from the atriopore to the anus, and thirteen from the anus to the tail."

Observations on the seven specimens obtained by Mr. Agassiz confirm most of these statements, as may be seen by inspecting Table 3, in which records from three of the seven individuals are given, and below these for comparison average records for the eastern form as given by Cooper (1903, p. 348) and by Punnett (1903, p. 362), and for the western by Andrews (1893, p. 242). It is obvious, as Cooper states, that in all these characters, except size, the eastern individuals agree with the western ones.

TABLE 3.

COMPARISON OF EASTERN AND WESTERN SPECIMENS OF *ASYMMETRON*.

No. of Specimen.	Length in mm.	Sex.	Gonads.	Myotome Formula.
1	17.5	♂	28	44 + 10 + 12 = 66
2	18	♀	shed	46 + 10 + 13 = 69
3	9	♀	26	43 + 9 + 11 = 63
East form ¹	23		29	44 + 9 + 13 = 66
West form ²	13		29	44 + 9 + 13 = 66

¹ Records for the eastern specimens as given by Cooper (1903, p. 348), and by Punnett (1903, p. 362).

² Records for the western specimens as given by Andrews (1893, p. 242).

The collection from the United States National Museum, which I had the privilege of studying, contained a few specimens of the West Indian *Asymmetron* donated by Dr. Andrews, and I therefore had the opportunity of making a close comparison between this and the eastern form. As a result of this comparison I found one structural feature in which the two sets of individuals consistently differed; this was the form of the caudal fin. In the West Indian specimens as figured by Andrews (1893, Plate 13, Figs. 1, 2), and as seen in the material before me (Plate 1, Fig. 3), the dorsal and particularly the ventral portions of the caudal fin in the vicinity of the myotomes were very broad, the fin becoming narrow and blade-like only on the urostyleoid process. In the Maldivan forms (Plate 1, Fig. 4) collected by Mr. Agassiz, the ventral portion of the caudal fin next the myotomes was only slightly broader than that under the urostyleoid portion, and the dorsal portion next the myotomes was no broader than that over the urostyleoid process. These features of the caudal fins in the two forms were so characteristically different in the material at my disposal that I do not hesitate to say that the seven Maldivan specimens certainly represent a species different from *A. lucayanum*, and I have therefore proposed the name of *Asymmetron orientale* for them.

While I am confident that the specimens collected by Mr. Agassiz are specifically distinct from *A. lucayanum*, I do not wish to be understood to imply that this species may not occur in the Maldives. Although the seven specimens examined by me have lengths not far from those of Cooper's specimens, they differ from the figure and description of these given by Cooper (1903, p. 348, Plate 18, Fig. 1) in the form of their caudal fins. The caudal fin, however, is an extremely delicate structure, and now that an important differential character has been found in it, a re-examination of its condition in Maldivan material heretofore supposed to be *A. lucayanum* would seem desirable before declaring this species to be an unquestionable member of the Maldivian fauna.

***Asymmetron macricaudatum*, sp. nov.**

Plate 2, Fig. 7.

Seven specimens of this species were in the collection of the Museum of Comparative Zoölogy. They were labelled "Salt Key Anchorage Fla." and were probably dredged on the Florida coast by the late Count Pourtalès. Two of the specimens were much curled and were of very little service for study; the remaining five were straight and in excellent preservation. The following description is based upon an examination of these.

The specimens varied in length from 14.0 mm. to 10.5 mm. and were over twelve times as long as they were deep (Plate 2, Fig. 7).

The dorsal fin is low, particularly in its middle and anterior extent. From the second myotome to a region somewhat posterior to the anus there are low fin-ray chambers and short fin-rays. The fin-rays are generally block-like in

outline and occur one for each chamber. There are as a rule four fin-ray chambers to a myotome.

Anteriorly the dorsal fin passes over into a small rostral fin. Posteriorly it is continuous with the much reduced caudal fin which invests the long urostyloid process dorsally and ventrally as a very narrow blade. The caudal fin is continuous with the rather broad ventral fin, in which there are neither fin-ray chambers nor fin-rays.

The myotome formula may be given as $43 + 5 + 14+ = 62+$. Between the anterior end and the atriopore the number of myotomes varies from 42 to 44, and between the atriopore and the anus it is usually 5. For the region posterior to the anus an exact number cannot be given, for the reason that the most posterior myotomes are so small that it is impossible to count them or determine with certainty where the system terminates. In the enumerations for this region given in Table 4, only the numbers that could be counted with certainty are given, though in every case more myotomes were probably present. This is indicated by suffixing a plus sign to the numbers for this region and to the totals.

A well marked chorda passes through the animal almost from end to end, and forms posteriorly a delicate, long, urostyloid process.

The nerve tube has a distinct anterior eye-spot, and a series of numerous smaller spots extending from the third myotome to about the region of the anus.

The gonads, which vary in number from twenty-three to twenty-eight, form a single series on the right side. In a specimen with twenty-six gonads they extended from the eleventh to the thirty-seventh myotome.

A summarized statement of the chief structural features of the five specimens examined is given in Table 4.

TABLE 4.

STRUCTURAL CHARACTERISTICS, ETC. OF *A. MACRICAUDATUM*.

No. of Specimen.	Length in mm.	Sex.	No. of Gonads.	Myotome Formula.
1	13.5	♀	26	$44 + 4 + 10+ = 58+$
2	10.5	♀	26	$42 + 5 + 17+ = 64+$
3	14.0	♀	shed	$42 + 5 + 19+ = 66+$
4	12.5	♂	28	$44 + 5 + 13+ = 62+$
5	11.0	♂	23	$43 + 5 + 11+ = 59+$

The presence of gonads only on the right side of the body and the well developed urostyloid process place this species unquestionably in the genus *Asymmetron*. It differs from all known species of this genus in the form of its

caudal fin, which is narrower even than that in *A. orientale*, and in the small number of myotomes intervening between the atriopore and the anus. Table 5 gives in a condensed way some of the more obvious differences between this and the other known species of *Asymmetron*.

TABLE 5.

SPECIES OF *ASYMMETRON* CONTRASTED.

Name of Species.	Length in mm.	No. of Gonads.	Myotome Formula.
<i>A. lucayanum</i> Andrews . . .	13	29	$44 + 9 + 13 = 66$
<i>A. orientale</i> , sp. nov.	23	29	$44 + 9 + 13 = 66$
<i>A. caudatum</i> Willey	20	30	$44 + 9 + 11 = 64$
<i>A. macrcaudatum</i> , sp. nov. .	13	26	$43 + 5 + 14+ = 62+$

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EXPLANATION OF PLATES.

All the figures are camera drawings of specimens preserved and dehydrated in alcohol and cleared in clove oil.

PLATE 1.

- Fig. 1. Right side of the anterior end of *Branchiostoma pelagicum* Günther. $\times 30$.
Fig. 2. Right side of the posterior end of *Branchiostoma pelagicum* Günther. $\times 30$.
Fig. 3. Left side of the posterior end of *Asymmetron lucayanum* Andrews, from the West Indies. $\times 40$.
Fig. 4. Left side of the posterior end of *Asymmetron orientale*, sp. nov. $\times 25$.

PLATE 2.

- Fig. 5. *Heteropleuron agassizii*, sp. nov.; right side. $\times 5$.
Fig. 6. *Heteropleuron parvum*, sp. nov.; right side. $\times 12$.
Fig. 7. *Asymmetron macricaudatum*, sp. nov.; right side. $\times 10$.